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Reduced Tillage Systems for Conservation and Profitability

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Farmers have been interested traditionally in using tillage systems which improve farm profits--both short and long term profits. The objective has been to use that tillage system which results in the highest return while protecting the soil to assure its long term use. In recent years, the question has been raised as to whether tillage systems are in fact using scarce land resources wisely. It has been estimated, for example, that 4 billion tons of soil are eroded each year of which 2 billion tons wash into streams and 1 billion tons reach tide waters.[2]

There is strong evidence from research results to indicate that tillage systems affect erosion and resulting flow of sediment into water bodies. Research at the Agricultural Research Service Station at Coshocton demonstrated that soil erosion under the "no tillage" and minimum tillage systems was substantially less than erosion under conventional tillage systems.[3]

Recently, state and federal agencies have proposed that efforts be made to further decrease pollution from soil erosion. Proposals have been made to establish regulations which would require farmers to lessen farmland erosion. Also, it has been suggested that reduced tillage systems may actually offer many farmers economic incentives to decrease erosion. If these incentives are present, education demonstrating the economic benefits of reduced tillage

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[1] Assistant Professor and Professor, Ag. Economics; Professor, Agronomy; and Research Associate, Ag. Economics, respectively.

[2] U.S. Environmental Protection Agency, "Methods of Identifying and Evaluating the Nature & Extent of Nonpoint Sources of Pollutants," EPA-430/9-73-014.

[3] Harrold, L. L., "Soil Erosion by Water as Affected by Reduced Tillage Systems," Proceedings Non-Tillage Systems Symposium, Columbus, Ohio, Feb. 21-22, 1972.

systems may be an alternative to the establishment and enforcement of regulations. The question is raised whether farmers can till the soil in a manner beneficial to their own economic interests while protecting the nation's soil resources, and thus prevent the pollution of the nation's water bodies without being subjected to governmental regulations requiring them to do so.

The purpose of this study is to investigate the profitability of various crop tillage systems to determine under what conditions both the farmers' desire for improved profits and society's interest in lessening pollution can be served.

From the farmer's point of view, several factors influence the profitability and choice of tillage systems. These are grouped into the following effects under alternative systems--

1. The impact which soil type has on crop yields (corn, soybean) under alternative tillage systems.

2. Average costs of production

3. Yield penalties incurred by those systems which result in relatively late plantings.

Our analysis investigates Ohio tillage conditions by using the soil divisions recently outlined by Van Doren, Tripplett, and Bone of the Department of Agronomy at OARDC.[4] There are five general groups of soils, and each have different implications for the yields of corn and soybeans which might be expected under alternative tillage systems. Three tillage systems are evaluated--conventional, minimum and no tillage. (The specific field operations for each of the three tillage systems are described later.)

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[4] Triplett, G. B., D. M. Van Doren, Jr., and Samuel W. Bone, "An Evaluation of Ohio Soils in Relation to No-Tillage Corn Production," Research Bulletin 1068, Ohio Agricultural Research and Development Center, Wooster, Ohio, December, 1973.

Yield Differences by Tillage System and Soil Type

Experimental work on tillage systems has been reported on three of the five major soil groups identified in Ohio. Soils with properties similar to these soils account for about 85 percent of Ohio cropland. A summary of the experimental yields for these three soil groups under different tillage systems is shown in Table 1. In these experiments, the no-tillage system had equal or superior yields when compared to the conventional tillage system in the first two groups and lower yields in the fourth group. Natural drainage appears to be the principal characteristic responsible for the differences between soils. The well drained soils show a positive response while the very poorly drained soils show a negative response to reduced tillage. It appears that reduced tillage practices could be used on about 60 percent of Ohio's cropland without reducing corn yields. In some cases yields would be increased. Preliminary research results indicate that reduced tillage systems could be used on soybeans with little effect on yields.

Average Costs of Production

Production costs are used which represent a "typical" commercial Ohio farm. This "typical" commercial farm has 600 crop acres of which 300 are in soybeans and 300 in corn. Its machinery complement allows corn planting to be completed by May 10 and soybean planting to be completed by May 25. Harvesting of soybeans is completed by October 7 and corn by November 7. Input costs differ between tillage systems on various soil types. The inputs which differ include labor, fuel, repairs, herbicides, and capital investment in machinery and operating costs. When all these differences are summed, however, the cost differentials are not great. For example, a savings in machine cost for the no-till is largely offset by the increased cost of herbicides. A

Table 1. Experimental Corn Yield Levels by Tillage System and Major Ohio Soils Groups

Major Ohio Soil Groups				Experimental Yields			
Number*	Characteristics	Representative Soils	Percent of Ohio Cropland	Soil Type	Conventional	Minimum	No-Till
					(bushels per acre)		
1	Moderately well to well drained, low organic matter, medium surface texture, mulch cover needed for no-till.	Cardington Celina Morley Miamian Rossmoyne Wooster	35	Wooster (well drained)	134	-	150
				Rossmoyne (Moderately well drained)	142	139	144
2	Somewhat poorly drained, low organic matter, medium surface texture, mulch cover needed for no-till. Requires drainage for yields listed.	Blount Crosby	25	Crosby (somewhat poorly drained)	137	144	143
4	Very poorly drained, high organic matter, fine surface texture. Requires drainage for yields listed.	Brookston Hoytville Pewamo	25	Brookston (poorly drained)	162	152	146
				Hoytville (very poorly drained)	135	-	114

* Research results have not been reported on soil groups three and five, which together account for only 15 percent of Ohio cropland.

summary of estimated total costs by tillage system and soil type is presented in Appendix A.

Yield Penalties

Yield penalties tend to handicap the system which delays crop planting. Generally, corn planting after early May reduces yield by one bushel per acre for each day planting is postponed. Yields may be decreased by as much as two bushels per day when planting is delayed until late May and early June. Delayed soybean plantings also result in yield losses after early May. Thus, the minimum and no-tillage systems would have an advantage over conventional tillage systems in terms of yield penalties.

The question is: how much do corn and soybean yields need to be increased to make the reduced tillage systems economical? The analysis provides answers to this question by a computer simulation of the operations of the three tillage systems on the typical farm. The three tillage systems use the following operations on corn-soybean cropland:

Season	Conventional Tillage System	Minimum Tillage System	No-Till System
Fall and Winter	Harvest Disc or chop stalks Mold board plow Apply P_2O_5 and K_2O	Harvest Chisel plow Apply P_2O_5 and K_2O	Harvest Apply P_2O_5 and K_2O
Spring and Summer	Disc-twice Apply herbicide Plant Apply NH_3 Cultivate	Disc Apply herbicide Plant Apply NH_3	Apply herbicide Plant Apply NH_3

All three tillage systems are assumed to have the same number of days available to do field operations in the spring and fall. The tractor sizes are the same under each system. The conventional system has the complement of equipment which allows timely field operations. The reduced tillage systems use that set of equipment which can be best utilized by the available tractors.

Analysis

Farmers may have an economic interest (i.e. more profits) and a societal interest (i.e. less sedimentation) in using minimum tillage systems. The objective of this analysis is to provide estimates of the net benefits (or losses) accruing to farmers using the various tillage systems. How much would the minimum tillage or no tillage system affect profits relative to the conventional system? How much net income, if any, would the farmer be sacrificing in order to improve societal welfare?

A computer simulation model is used to represent the crop production on farms representing each of the five soil types where OARDC research has been completed. Experimental results from Wooster, Rossmoyne, Crosby, Brookston, and Hoytville soils are used as a basis for establishing yields for the five simulated farm situations. These five soil types represent about 85 percent of Ohio cropland (Table 1).

Initially the "typically" 50-50 corn-soybean cropping pattern is analyzed. Then a 100 percent corn system is compared to the typical system, thus, a total of six tillage and cropping systems are analyzed on each of the five soil types. These are the following:

Table 2. Six Tillage and Cropping Systems on Each of the Five Simulated Farm Soil Situations

Cropland Planted to 300 Acres Soybeans & 300 Acres Corn	Cropland Planted to 600 Acres Corn
1. Conventional Tillage	4. Conventional Tillage
2. Minimum Tillage	5. Minimum Tillage
3. No-Tillage	6. No-Tillage

The computer simulation model used is the Corn-Soybean Crop Model developed by Purdue University. The model is a linear programming model which determines the profit maximizing combination of production processes given a set of resources existing on a particular farm. The model allows a specification of average yields, yield timeliness, penalties resulting from late cropping operations, field time available to do field work during several periods of the growing season, the amount and efficiency of labor and machinery on the farm, the costs of inputs used in the production process, and the prices of the products.

Our analysis forces each simulated farm (soil) situation to use two cropping patterns (all corn and a 50-50 corn soybean mix) under conventional, minimum, and no-tillage systems. A comparison is made of the profits under the minimum and no-tillage systems relative to profits with conventional tillage. (Table 3).

Table 3

Profits (Losses) Per Acre Resulting From Changing to Minimum Tillage and No Tillage Systems for Simulated Farms Situations

		Minimum Tillage[2]		No-Tillage	
		Cropping Patterns		Cropping Patterns	
Ohio Soil Group[1]	Soil Type	50 Percent Corn and 50 Percent Soybeans	100 Percent Corn	50 Percent Corn and 50 Percent Soybeans	100 Percent Corn
		Increased (decreased) profit per acre when compared to conventional tillage system			
1	Wooster	ND	ND	$13	$39
1	Rossmoyne	$-1	$-2	6	12
2	Crosby	12	19	13	19
4	Brookston	-14	-12	-24	-22
4	Hoytville	ND	ND	-26	-39

1/ See Table 1

2/ Experimental yield data not available for minimum tillage on Wooster and Hoytville soils.

The results in Table 3 show that reduced tillage systems are profitable relative to conventional tillage systems for the soil groupings represented by the Wooster, Rossmoyne, and Crosby soil types. For these well, moderately well, and somewhat poorly drained soils, considerable economic advantage lies with the reduced tillage system. As the proportion of corn in the cropping pattern increases on these soils, this economic advantage becomes even greater. For example, minimum tillage results in $19/acre greater profits than conventional tillage with all the Crosby soils cropland in corn while profits improve $12 with 50 percent corn, 50 percent soybean mix on these same soils. Due to the severe timeliness penalties associated with late corn planting, intensive corn production favors the time saving reduced tillage systems.

The flat, fine textured Brookston and Hoytville soils favor the conventional tillage system. Profits are reduced by approximately $13 per acre if the minimum tillage is used on the Brookston soils. Furthermore, profits are reduced by $24-$39/acre when the no-tillage system is used on these soils.

Conclusions

Societal interests and the farmers' own economic interests appear to be in harmony on the majority of Ohio soils. The farmer benefits economically by moving to a reduced tillage system which also lessens the erosion and resulting costs of sedimentation borne by the non-agricultural sectors. It appears that a strong educational effort in these areas would be appropriate in order to lessen erosion. The educational effort would be directed at improving the farmer's knowledge of the impacts of tillage systems and how to efficiently use these systems.

In the fine textured, wet soil areas two questions need to be asked in addressing the soil erosion problem:

1. How serious is erosion in these areas? Is the problem serious enough to reduce net income \$12-\$39 per acre by moving to reduced tillage systems in order to lessen erosion?
2. What can be done about erosion on these wet, fine textured soils if it is significant? How effective are reduced tillage systems in lessening erosion on these flat soils? Is it fair to mandate that producers must use reduced tillage systems if erosion control is minimal?

Additional research on reduced tillage systems on the wet, fine textured soils may help improve yields and thus reduce the present differences between conventional and reduced tillage systems.

These questions merit additional study to determine the degree to which societal interests and the economic well being of agricultural producers can be reconciled.

Appendix A. Costs Per Acre and Yield Levels Used in Analysis and Computer Simulation Results by Soil Type, Tillage System and Cropping Pattern

Tillage System and Soil Type	Costs Per Acre: Variable Corn Cost	Variable Soybean Cost	Fixed Cost[1/]	Total Cost: 100% Corn	Total Cost: 50% Corn 50% Soybeans	Yield Levels[2/]: 100 Percent Corn	50% Corn 50% Soybeans: Corn	50% Corn 50% Soybeans: Soybeans	Profit Per Acre[3/]: Total Profit: 100% Corn	Total Profit: 50% Corn 50% Soybeans	Increase Over Conventional Tillage: 100% Corn	Increase Over Conventional Tillage: 50% Corn 50% Soybeans
	$/Acre					(Bushels Per Acre)			$/Acre			
Conventional Tillage												
Wooster	$131.79	$74.48	$117.40	$249.19	$220.54	113	118	36	$33.31	$25.96	$ -	$ -
Rossmoyne	132.79	74.48	117.40	250.19	221.04	119	125	38	47.31	39.71	-	-
Crosby	132.07	74.48	117.40	249.47	220.68	115	120	36	38.03	28.32	-	-
Brookston	136.31	74.48	117.40	253.71	222.80	135	143	43	83.79	74.20	-	-
Hoytville	127.18	74.48	117.40	244.58	218.23	114	118	32	40.42	17.27	-	-
Minimum Tillage												
Rossmoyne	132.79	75.10	114.50	247.29	218.44	117	122	38	45.21	38.56	- 2.10	- 1.15
Crosby	133.05	75.10	114.50	247.55	218.58	122	126	37	57.45	40.67	19.42	12.35
Brookston	136.28	75.10	114.50	250.78	220.19	129	134	41	71.72	60.06	-12.07	-14.14
No-Tillage												
Wooster	131.64	75.00	113.93	245.57	217.25	127	132	33	71.93	38.50	38.62	12.54
Rossmoyne	131.47	75.00	113.93	245.40	216.16	122	127	38	59.60	46.09	12.29	6.38
Crosby	131.26	75.00	113.93	245.19	217.06	121	125	37	57.31	40.94	19.28	12.62
Brookston	134.37	75.00	113.93	248.30	218.62	124	129	39	61.70	49.88	-22.09	-24.32
Hoytville	124.62	75.00	113.93	238.55	213.74	96	100	29	1.45	-8.99	-38.97	-26.26

1/ Fixed costs include an $80.00 per acre land charge.
2/ Yield levels are approximately 83 percent of experimental levels for the 100 percent corn cropping pattern, higher levels for the 50 percent corn cropping pattern reflect earlier average planting of the smaller corn acreage.
3/ A corn price of $2.50 and a soybean price of $5.50 per acre were used in the analysis.